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The W. L. Newman Phosphate Mine, Juniata County, Pennsylvania

William D. Carter

COMMONWEALTH OF PENNSYLVANIA
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by William D. Carter
U. S. Geological Survey

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PREFACE

This report on a phosphate deposit in Juniata County will be of particular interest to developers of phosphate occurrences and to those interested in the origin of such deposits.

The Newman phosphate mine is a rather unusual occurrence in Pennsylvania. It is hoped that this report will not only contribute to a better understanding of this type of mineral occurrence, but may also be of assistance in locating larger, economic occurrences of phosphate in this region.

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The W. L. Newman Phosphate Mine, Juniata County, Pennsylvania*

by

W. D. Carter
U. S. Geological Survey

ABSTRACT

Phosphate was discovered and mined from Lower Devonian rocks at the W. L. Newman property, Juniata County, Pa., near the end of the last century. Recent studies of this deposit show that phosphate occurs both as carbonate fluorapatite in oölitic calcareous nodules at the contact of Onondaga Limestone with Ridgeley Sandstone and as veinlets and vug fillings of wavellite and crandallite in the Shriver Chert. This is the first reported occurrence of crandallite, an aluminum phosphate mineral of secondary origin, in Pennsylvania.

The mine workings are small and scattered over an area that is about 1,000 feet long and 250 feet wide. Of the two zones mined, the upper nodular zone is apparently thin, but its exact thickness has not been determined. The lower secondary aluminum phosphate zone was mined by underground methods along a layer about 2.5 feet thick. Rock as much as 20 feet below this layer is mineralized by veinlets of wavellite and crandallite. Mineralized phosphate rock fragments range in grade from a trace to as much as 26 percent P_2O_5. The areal and stratigraphic distribution is still only partly known.

Although the Newman phosphate deposit is small and seems to consist largely of aluminum phosphate minerals, further search and study of this and similar deposits are needed to appraise adequately the phosphate resources of Devonian rocks in Pennsylvania and other areas of the Appalachian region.

INTRODUCTION

Ihlseng (1896) was the first to report the presence of phosphate rock from localities in the Reeds Gap-East Waterford area of Pennsylvania. He investigated areas where the soils were known to be more fertile than elsewhere and found phosphatic nodular pebbles strewn over the soil. Ihlseng found that the pebbles could be classed into three types: "(1) a white vesicular rock, soft, tasteless and dry; (2) red nodules resembling concretions found within limestone; (3) blue limestone fragments, odoriferous on fracture and dense in texture." All pebble types contained more than 12 percent phosphoric acid. Furthermore, Ihlseng reported that the entire sequence of Devonian rocks, presently included in the Onondaga, was weakly phosphatic.

* Publication authorized by the Director, U. S. Geological Survey.

Phosphate was mined between 1899 and 1904 from the W. L. Newman farm and other nearby properties in Juniata County, Pa., by the Tuscarora Fertilizer Co., which built a processing plant having a daily capacity of 200 tons (Parker, 1901, p. 494-495). During the 5-year period a total production of nearly 4,000 long tons, having a value of about $17,000 was reported (Hovey, 1904).

Although production was initiated at the Newman farm property, then known as the Ross farm, some production also may have come from the Moore farm, about 3 miles to the northeast, and from Reeds Gap to the northwest. A summary of production from the deposits as recorded by Hovey (1904) is shown below:

Years	*Quantity (long tons)*	*Value*
1899	2,000	$ 9,000
1900	900	4,500
1901	893	3,000
1902	100	400
1903	—	—
1904	100	200
Total	3,993	$17,100

Mining at the Newman property was by open-trench and underground room-and-pillar methods. The workings, now mostly covered and overgrown, extend along the strike of the outcrops for about 1,000 feet in a belt 100 to 250 feet wide. The size of the dumps indicates that production may have ranged from a few tons to a few hundred tons from each working. The phosphate rock was crushed and processed at a siding (then known as Ross Farm Station) of the Tuscarora Valley Railroad on the Newman farm. About 200 tons of the first year's production of ore was crushed for direct application to the soil, and the remainder was manufactured into superphosphate (Parker, 1901, p. 494). Production declined after 1899 and ceased after 1904. Although the reasons for failure of the business have never been clearly reported, lack of local demand and inability to compete with higher grade deposits elsewhere were probably prime factors.

The deposits were visited briefly in 1931 by a group which included Prof. B. L. Miller of Lehigh University, whose description of the mine is quoted by Stone (1939, p. 28).

The purpose of this report is to present maps and new chemical and mineralogical data from the Newman prospect of central Pennsylvania. It is hoped that this will encourage renewed search for phosphate resources in the Appalachian region employing modern exploration techniques and possibly result in the discovery of deposits suitable for local use.

ACKNOWLEDGMENTS

The author is very grateful to Mr. W. L. Newman for granting permission to study the deposit and drill on his property. Charles Withington of the U. S. Geological Survey assisted the author in the field and Mary E. Mrose and William M. Turner of the U. S. Geological Survey helped collect mineral specimens from the area. Mrose confirmed the presence of wavellite and determined the presence of crandallite by X-ray powder diffraction techniques. Their assistance is greatly appreciated. The author also wishes to acknowledge the helpful comments on this paper made by R. E. Van Alstine and James B. Cathcart of the U. S. Geological Survey and Donald M. Hoskins of the Pennsylvania Geological Survey.

LOCATION

The Newman phosphate property is on the west side of Tuscarora Creek approximately 2,000 feet due west of the W. L. Newman farm, 4 miles southwest of East Waterford, Lack Township, Juniata County, Pa. (Figure 1). The geographic coordinates of the deposit are

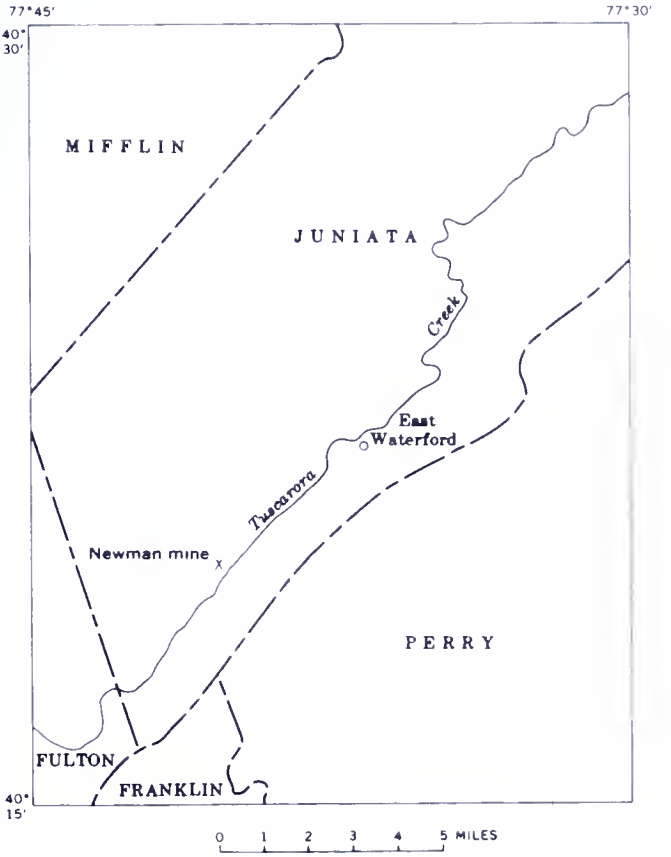

Figure 1. Index map of the East Waterford, Pa. 15-minute quadrangle, showing location of the Newman phosphate mine.

lat 40°19′40″ N., and long 77°40′00″ W. and, although not shown on the map, it is in the Blairs Mills, Pa. 7½-minute quadrangle, the southwest one-quarter of the East Waterford, Pa. 15-minute quadrangle. It is 500 feet west of Tuscarora Creek at an elevation of about 700 feet, on the northwest side of a low, heavily wooded ridge that parallels Creek Ridge on the northwest. The property is accessible by a truck trail that starts from Route 75 directly opposite the Newman home and leads northwest, fording Tuscarora Creek, and thence southwest to the mine. Travel to the mine in periods of wet weather and high water is not feasible by the present route of access.

GEOLOGY

The geology of the area has not been mapped in detail, but Figure 2 shows the access route and most obvious geological features on the surface and in the mine workings. Ihlseng (1896) and others recognized that the phosphatic rocks occurred with gray chert below what is now known as the Ridgeley Sandstone* of the Oriskany Group of Devonian age, and in yellowish-brown weathered limestone, marl, and shale that overlie the Ridgeley. Early workers assigned the rocks below the Ridgeley to the Helderberg Group. However, the subsequent discovery of Oriskany age fauna in the cherty limestone layers below the Ridgeley enabled Schuchert and others (1913, p. 90-96) to assign these rocks to the Shriver Chert, the basal formation of the Oriskany Group in Pennsylvania, Maryland, and northern West Virginia.

The exact thickness of the Shriver Chert at the Newman property is uncertain. Regional investigations and compilations of drill-hole data by Jones and Cate (1958) show that it is probably about 75 feet thick. Of this thickness, the upper 10 to 20 feet have been prospected for phosphate. Most of the mine workings extend along the uppermost layers near and at the contact with the Ridgeley Sandstone. Examination of the underground workings indicates that a zone 2 to 3 feet thick at the top of the Shriver was considered richest in phosphate. Figure 3 shows the distribution of phosphatic material within the stratigraphic sequence of the region.

The Ridgeley Sandstone at the Newman farm is coarse-grained to conglomeratic, iron-stained, calcareous and highly fossiliferous, quartz sandstone. It is poorly exposed and usually weathered, and crops out discontinuously because of soil cover and vegetation. Fragments of it

* The stratigraphic names used in this report do not conform to names accepted by the Pennsylvania Geological Survey.

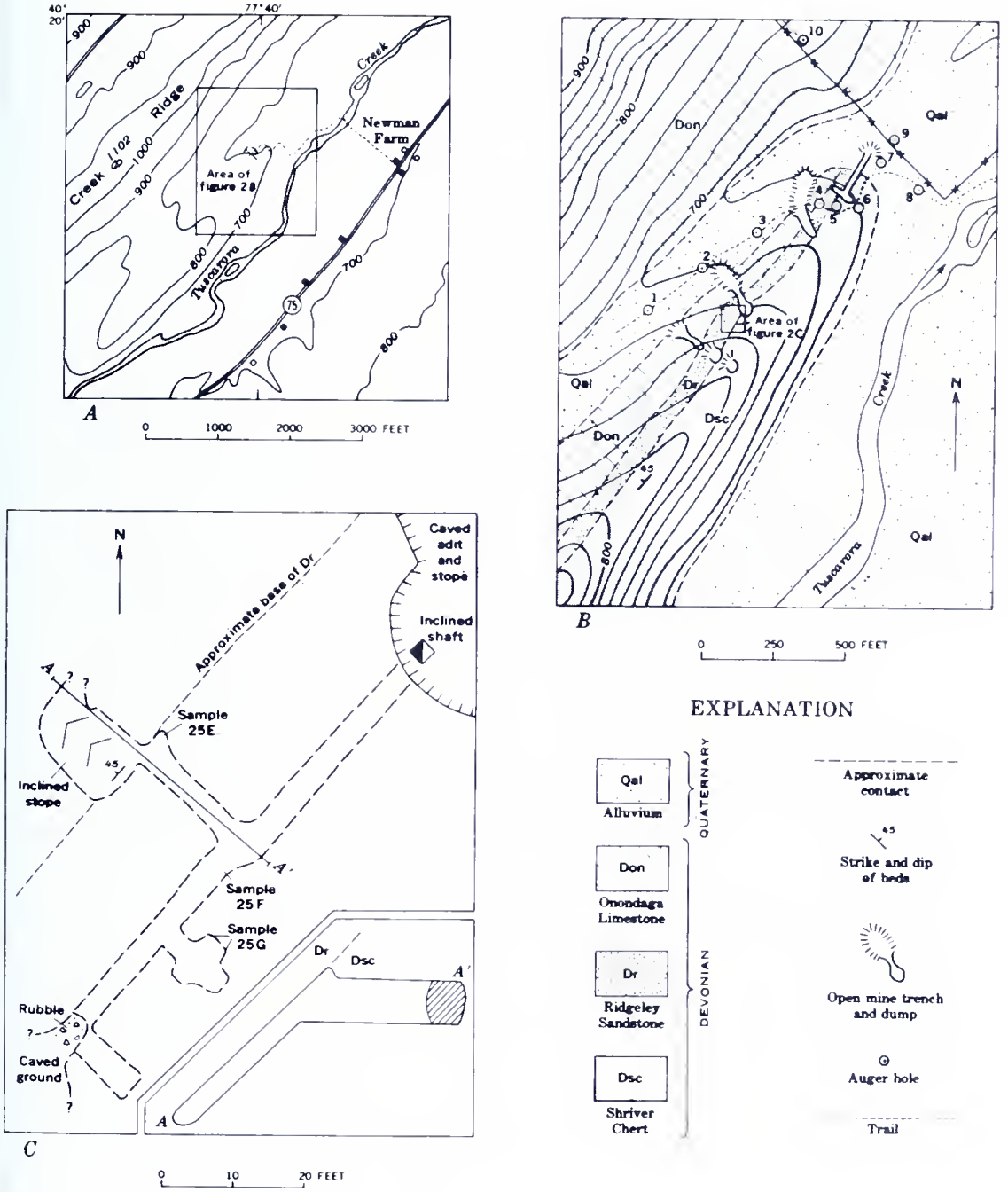

Figure 2. A. Map showing access route from the W. L. Newman farm to the abandoned phosphate mine. Contour interval 100 feet.

B. Generalized geologic map of the Newman phosphate mine showing location of surface workings and auger holes. Contour interval 20 feet.

C. Sketch map of underground mine workings at the W. L. Newman phosphate mine showing sample localities.

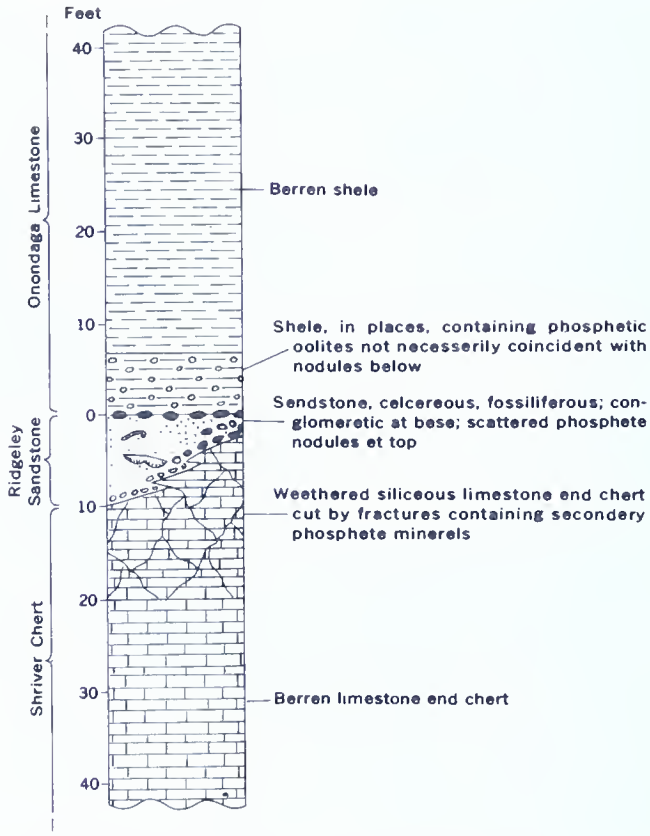

Figure 3. Generalized columnar section shawing distributian af phasphatic material in part af the Oriskany Graup and Onandaga Limestane at the W. L. Newman praperty.

are strewn on the dip slope of low ridges that parallel Tuscarora Creek on the northwest. Jones and Cate (1958) show an average thickness for the Ridgeley of about 40 feet from oil-well data in the area. The Newman prospect is on the easternmost outcrop belt of the Ridgeley where it is highly lenticular, ranging in thickness from less than a foot to nearly 60 feet. Exposures near and in the mine workings suggest that locally the Ridgeley is less than 10 feet thick. Shallow auger drilling of the soils west of the mine shows that brownish-black to grayish-green shale of the Onondaga Limestone overlies and rests conformably on the Ridgeley. The limestone beds of the Onondaga which overlie the Ridgeley in many places to the northeast are apparently absent in this area.

The stratified rocks strike N. 45° E., dip 45° NW., and form the northwest limb of the Tuscarora anticline. The axis of the anticline is about 2.5 miles to the southeast. The corresponding syncline is called the Creek Ridge syncline; its axis is about 1.5 miles to the northwest.

The origin of the Pennsylvania phosphate deposits is believed to be similar to Tertiary deposits of the Atlantic Coastal Plain where nodules

and oölites probably represent primary deposition under shelf conditions. At the Newman property local weathering conditions have subsequently modified both the thickness of the phosphate zone and the mineralogy, resulting in a secondary modification.

MINE WORKINGS

The surface workings extend along the nose of the low, northeast-trending ridge nearest Tuscarora Creek. They consist mainly of four trenches spaced approximately 200 to 400 feet apart along a strike for about 1,000 feet. The northernmost trench may extend along the sandstone-chert contact for about 150 feet. This trench may have been an adit, now caved, that once was connected to underground workings and served as the major haulageway and for drainage. More likely, however, it was merely a prospect trench.

The second trench is 150 feet to the southwest and crosscuts the formation contacts. A low elongate waste dump, now overgrown, extends northward from this trench into the valley west of the access road.

The third and largest of the trenches lies 350 feet southwest of the second trench. It also crosscuts the formation contacts and is about 90 feet long, 45 feet wide, and 25 to 30 feet deep at its eastern end. The circular portion at the east end is caved. W. L. Newman (oral commun., 1964) reported that in recent years he entered the underground workings from this area; after several attempts to reopen the adit, the author also entered the underground workings from this area.

The southernmost surface workings include three shallow exploration pits, dug more or less on a northwest line perpendicular to the strike of the beds. The lowest pit explored the top of the Ridgeley Sandstone, and the dump from this pit contains many phosphatic nodules of which sample 25A is considered to be representative. The upper two pits explored the lower part of the sandstone and the upper part of the siliceous Shriver limestone sequence. No phosphatic material was found in either of them.

A shallow trench, northeast of the uppermost pit of this group of three, was once used as an open limestone furnace or "pot" kiln of the type described by Miller (1925, p. 55). The trench contains a 3-foot thick zone of white, soft, chalky material which Mary E. Mrose of the U. S. Geological Survey identified by X-ray analysis as calcite. Veinlets of transparent, colorless, interlocking platy crystals crosscut the chalky material. X-ray identification of these crystals indicates portlandite, $Ca(OH)_2$, which probably formed by hydration of roasted limestone.

A reddish-brown zone of altered rock fragments surrounds the "chalk" and is also in contact with siliceous limestone in the base of the pit.

Underground workings, reached through a small hole in the floor of the largest circular caved area of the main adit (Figure 2C), extend southwest along the strike of the beds for about 70 feet. The southern end of this drift is marked by a large pile of rubble and an open room above, which was deemed too hazardous to enter. This caved area may correspond to an open surface pit, not shown in Figure 2, located approximately the same distance south of the large trench. Between these two points are three crosscuts, two extending southeast and one northwest. The northwest crosscut is about 20 feet long, and joins a stope inclined 45° which extends downdip for about 20 feet. The stope was not examined because of its steepness and the danger presented by rotten timber. Nevertheless, the stope shows that phosphate rock was mined to a thickness of 2 to 3 feet, for about 10 feet along strike, and about 20 feet downdip. Lower workings may extend northeastward as a sublevel at the base of the stope, but if so they are hidden by a curve in the wall. Sample 25E is a channel sample taken across the 2.5-foot-thick mined layer on the north side of the drift at the top of the inclined stope.

Two crosscuts extend to the southeast and part of one of these crosscuts has been widened to about 8 feet. Sample 25G is a collection of grab samples across the north wall of this stope (Figure 2C).

MINERALOGY

Phosphatic material in Devonian rocks of the northern Appalachian is known to occur 1) in oölitic shales of the Onondaga Limestone which overlie the Ridgeley Sandstone, 2) in nodular concentrations at the top of the Ridgeley and 3) as secondary phosphate minerals in fractures and vugs in weathered siliceous limestone below the Ridgeley. The Newman prospect, however, consists of nodules at the top of the Ridgeley and veins of secondary phosphate in the underlying Shriver Chert. The nodules from the Ridgeley Sandstone are hard, heavy, dark gray to black, and extremely fine grained on the inside. Most weathered surfaces are yellowish brown, but some have a white, powdery efflorescent coating that is typical of weathered phosphatic material. Thin sections show that the nodules are composed of very fine-grained, unidentified fossil fragments and small oval pellets or oölites of phosphate cemented by calcium carbonate. Etching the surface with acid shows that many of the fossils are moderately calcareous and that the surrounding material is a fine dolomitic clay which probably formed as a thin bed at the top of the Ridgeley Sandstone.

The oölites in the nodules are of fluorapatite and internally show alternating light to dark brown concentric bands. They are ovoidal and range from about 0.25 mm to 1.00 mm in longest dimension. They seem to be similar to phosphatic pellets of the carbonate-fluorapatite type found in the Chattanooga Shale of Tennessee; smaller, pale green grains of glauconite (X-ray and spectroscopic identification) are also present but sparse. The oölites are abundant throughout the nodules, but the abundance of the nodules and thickness of the layer from which they come is unknown. If similar to other localities where oölites have been observed, they may occupy a shale zone a few inches to as much as 7 feet in thickness, as for example near Warfordsburg, Pa.

Secondary minerals consisting mainly of wavellite $Al_3(PO_4)_2(OH,F)_3 \cdot 5H_2O$, and lesser amounts of crandallite, $CaAl_3(PO_4)_2(OH)_5 \cdot H_2O$, are in fractures and cavities of the chert layers below the nodular zone and Ridgeley Sandstone. Wavellite occurs as white, pale yellow to clear, vitreous to chalky, bladed crystal clusters radiating from the walls of small fractures, and cavities left by dissolved shell material. One partly replaced shell had a discrete, glassy, orthorhombic crystal of wavellite extending into an open cavity.

Crandallite, identified by Mary E. Mrose of the U. S. Geological Survey through X-ray diffraction methods, occurs mainly as a white to vitreous chalcedonic, platy mineral crust, filling cavities in company with wavellite, and as chalky plates on bedding surfaces of shaly material that separate layers of the Shriver Chert. The cavity-filling variety is purest and provides the best material for X-ray study.

Amblygonite, a fluophosphate of aluminum and lithium, was tentatively reported by Ihlseng (1896). Its presence, however, has never been firmly established, though Stone (1939, p. 25) implies that it has. It is very unlikely that it will ever be found in deposits such as the Newman prospect, for the typical occurrence of amblygonite is in lithium-bearing pegmatites as a primary mineral with 6 to 10 percent Li. The absence of lithium in the chemical and spectrographic analysis of samples studied for this report further negates the occurrence of amblygonite at the Newman mine. One may conclude, therefore, that Ihlseng recognized two phosphate minerals; he correctly identified wavellite by characteristic radiating bladed crystals. It is understandable that he did not recognize "crandallite," for it had not yet been identified as a distinct mineral species.

Although crandallite and wavellite are not presently being mined in the United States, large phosphate resources in Florida composed of these minerals have been described by Altschuler and others (1956),

Cathcart and McGreevy (1959), and Cathcart (1963). The Tennessee Valley Authority operated a pilot plant to produce fertilizer from the aluminum phosphate zone (Cathcart, 1963, p. 65). Such resources may eventually become a source of both aluminum and phosphate.

ANALYSES

Chemical and spectrographic analyses were made of 7 rock samples and 10 soil samples. Four of the rock samples were selected grab samples (WDC-64-25A through D) from surface dumps and outcrops, and three (25E through G) were selected from underground workings. Megascopic descriptions of the rock samples are given in Table 1. The soil samples (1A to 10A) came from the upper 3 to 5 feet of the 10 auger holes shown on Figure 2B. A total of 156 feet was drilled in these holes; description and analyses of the lower parts are included in Table 4.

Chemical composition of the phosphatic materials is extremely variable (Table 2). The oölitic phosphate nodule of sample 25A contains approximately 24 percent P_2O_5, and the weathered chert, sample 25D containing visible wavellite-crandallite veinlets, has about 26 percent P_2O_5. The fluorine content of the nodule is about 1.0 percent. Both materials are high in CaO (34 to 36 percent) with lesser amounts of

Table 1.—*Description of rock samples from Newman phosphate property*

WDC-64-25A—Phosphate nodule, dark rusty brown having white efflorescent stain on upper surface; 1 inch thick, 3 inches long, irregular shape; dark gray to bluish black and oölitic when broken open; from top of Ridgeley Sandstone at southernmost dump (Figure 2B).

WDC-64-25B—Shriver Chert, light brown, highly weathered, relatively soft and punky, cut by wavellite vein 3 mm thick; microcrystalline quartz surrounds larger quartz grains; very fine-grained wavellite fills vugs and replaces fossils; fragment from wall to pit above shaft to underground workings (Figures 2B, 2C).

WDC-64-25C—Shriver Chert, as in 25B but without visible wavellite; same locality (Figure 2B).

WDC-64-25D—Shriver Chert, light brown to white; wavellite/crandallite as cement and microcrystalline filling of vugs; scattered grains of quartz; from dump near largest pit and adit (Figure 2B).

WDC-64-25E—Shriver Chert, light brown, weathered to sandy powder; from mined layer 2.5 feet thick at inclined stope of underground workings (channel sample) (Figure 2C).

WDC-64-25F—Shriver Chert, light yellow-brown with black manganese stain near veinlets and vugs showing traces of wavellite and crandallite (Figure 2C).

WDC-64-25G—Shriver Chert, light yellowish-brown, moderately soft and punky with manganese stain but no visible phosphate minerals (Figure 2C).

Table 2.—*Chemical composition of seven rock samples from the W. L. Newman phosphate mine, East Waterford, Juniata County, Pa.*

[X-ray fluorescence analyses supplemented by rapid rock analysis techniques described by Shapiro and Brannock (1962). Analyst, Paul Elmore, U. S. Geological Survey]

Lab. No.	*166375*	*163376*	*163377*	*163378*	*164059*	*164060*	*164061*
Field No.	*WDC-64-25A*	*WDC-64-25B*	*WDC-64-25C*	*WDC-64-25D*	*WDC-64-25E*	*WDC-64-25F*	*WDC-64-25G*
SiO_2	15.3	84.8	87.1	28.7	76.3	69.8	74.7
Al_2O_3	8.7	4.9	4.7	3.1	5.2	10.0	9.8
Fe_2O_3	3.6	2.9	2.6	2.6	5.3	5.0	4.8
FeO	3.2	.04	.16	.10	.04	.04	.16
MgO	2.2	.40	.62	.71	.15	.40	1.7
CaO	35.9	.53	.04	33.6	4.8	3.2	.31
Na_2O	.00	.00	.00	.36	.06	.09	.05
K_2O	.57	.37	.72	.28	.91	1.2	1.6
H_2O-	1.1	.36	.90	.58	.46	1.1	1.5
H_2O+	2.7	2.2	2.0	2.1	2.4	4.2	3.4
TiO_2	.10	.14	.24	.07	.56	.43	.49
P_2O_5	23.8	2.1	.57	25.8	3.5	4.0	1.1
MnO	.00	.00	.04	.00	.08	.13	.08
CO_2	2.4	.06	.18	.78	.20	.12	.10
Sum	99.57*	98.80	99.87	98.78	99.96	99.71	99.79

* Fluorine, not generally reported in rapid rock analyses, was later found by J. W. Budinsky, U. S. Geological Survey, to be present in sample WDC-64-25A as 1.0 percent F. It was not looked for in the other samples shown above.

SiO_2. Where no öolites, wavellite, or crandallite are visible, both the phosphate and calcium content are very low, and silica is the dominant component. Analyses of samples 25E and 25F from the upper part of the Shriver Chert, exposed in the subsurface workings, indicate that the chert contains 3.5 to 4.0 percent of P_2O_5 in the upper 15 to 20 feet. No estimate can yet be made on the average phosphate content of the formation.

Table 3 shows the percentage range of minor elements (less than 1 percent) in the seven samples from the Newman phosphate property, as determined by semiquantitative spectrographic analyses. The most striking feature shown by these analyses is the rather high percentage (0.15 to 0.20 percent) of zinc that occurs in both mineralized and nearly barren samples of Shriver Chert. Where zinc is present, molybdenum occurs in parts per thousand, and nickel has a somewhat higher concentration than normal in three of four samples. The rare earth, cerium, is present in significant amounts in two samples—0.5 percent in sample 25A and 0.03 percent in sample 25E.

Table 3.—*Semiquantitative spectrographic analyses of minor elements contained in rock samples from the W. L. Newman phosphate mine, East Waterford, Pa.*

[Analysis by J. L. Harris, U. S. Geological Survey]

		*Percentage range of minor elements**			
Sample No.	*Lab. No.*	*0.X*	*0.0X*	*0.00X*	*0.000X*
WDC-64-25A	163375		Ce,Cr,Sr,V	B,Ba,Cu,Ga, La,Y	Be,Sc,Yb,Zr
WDC-64-25B	163376		Cu,Pb	B,Ba,Co,Cr, Ni,Sr,V,Y,Zr	Ag,Be,Ga,Sn, Yb
WDC-64-25C	163377		Ba	B,Co,Cu,Ni, Pb,Sr,V,Y,Zr	Be,Cr,Ga,Sc, Sn,Yb
WDC-64-25D	163378	Zn	Sr,Y	B,Ba,Co,Cr, Cu,Ni,Pb,V	Ag,Be,Mo,Yb
WDC-64-25E	164059	Zn,Zr	Ba,Ce,Ni,Y	B,Co,Cr,Cu, Nb,Pb,Sc, Sr, V,Yb	Be,Ga,Mo
WDC-64-25F	164060	Zn	Ba,Co,Ni, Sr,Zr	B,Be,Cr,Cu, Ga,Pb,Sc,V, Y	Mo,Yb
WDC-64-25G	164061	Zn	Ba,Co,Cu, Ni,Pb,Zr	B,Be,Cr,Ga, Sc,Sn,Sr,V,Y	Mo,Yb

* Results were originally reported in percent to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15 and 0.1, etc.; which represent approximate mid points of group data on a geometric scale. The assigned group for semiquantitative results will include the quantitative value about 30 percent of the time. The values for elements in the 0.X column range from 0.1 through 0.9, and similarly for the other columns. The order of presentation of the elements within a percentage range for each sample is from highest to lowest percentage.

Table 4 shows the relative concentrations of phosphate and uranium in soils from the upper 3 to 5 feet of 10 power-auger holes drilled in the vicinity of the Newman mine. The locations of the holes are shown on Figure 2B. Holes 8, 9, and 10 are rather distant from the mine and show that the background composition of the soils is 0.1 percent P_2O_5 and .0003 to .0004 percent U. The phosphoric acid content is within the normal range of 0.07 to 0.25 percent P_2O_5 for good productive soils, according to Van Slyke (1932, p. 85). Holes 8 and 10 are in fields which have been tilled and probably fertilized; hole 9 is in the center of a road (not shown on Figure 2B) along which fertilizers have been hauled. Soils nearer the deposits contain 0.2 to 0.3 percent P_2O_5, and thin soils on

Table 4.—*Partial chemical analyses of samples from 10 auger holes on the W. L. Newman property, East Waterford area, Juniata County, Pa.*

[J. Budinsky and S. M. Berthold, Analysts, U. S. Geological Survey]

NA stands for Not Analyzed; Y, yellow; Br, brown; Gy, gray; Gn, green, Bk, black; L, light; D, dark; R, red; Or, orange; and TD, total depth

Auger Hole No.	*Depth*	*Sample No.*	*Color and Description*	*Percent* P_2O_5	*Percent U*
1	0-5′	1A	YBr, clay soil	.3	.0006
	5-10′	1B	YBr, clay soil	.18	NA
	10-15′	1C	YBr, clay soil	.15	NA
	15-20′	1D	YBr, clay soil	.15	NA
	20-25′	1E	GyBr, lumpy clay (damp)	.10	NA
	25-30′	1F	GyGn clay (damp)	.29	NA
	30-33′TD	1G	GyGn shale (flakey)	.19	NA
2	0-5′	2A	LBr shaly soil	.2	.0005
	5-10′	2B	LBr shaly soil	.17	NA
	10-15′	2C	BrGn shaly soil	.12	NA
	15-20′	2D	GyGn shaly soil	.10	NA
	20-25′	2E	GyGn shaly soil	.17	NA
	25-30′	2F	GyGn clay (damp)	.37	NA
	30-	2G	DGyBk shale	.34	NA
3	0-5′	3A	YBr sandy soil	.2	.0004
	5-10′	3B	YBr sandy clay soil	.32	NA
	10-15′	3C	YBr chunky clay	.26	NA
	15-20′	3D	BrGn earthy clay	.12	NA
	20-25′	3E	LGyGn clay	.28	NA
4	0-5′	4A	LOrBr sandy soil, sandstone fragments at 3 feet	.4	.0007
	5-10′	4B	YBr clay (dry), sandy in upper foot	.45	NA
	10-15′	4C	Br shaly soil	.17	NA
5	0-3′	5A	YBr sandy soil	.7	.0006
6	0-3′	6A	YBr sandy soil	.4	.0004
7	0-5′	7A	LBr sandy clay soil	.3	.0005
	5-10′	7B	LBr-RBr clay and soil	.22	NA
8	0-5′	8A	DBr sandy clay soil	.1	.0003
	5-10′	8B	DBr sandy clay w/gravel	.7	NA
9	0-5′	9A	LBr sandy soil	.1	.0004
	5-10′	9B	LBr sandy soil, clay, pebbles	.18	NA
	10-15′	9C	DGy mud (wet)	.21	NA
	15-20′	9D	DGy mud (wet)	.28	NA
	20-22′	9E	DGy mud (wet)	.32	NA
10	0-5′	10A	Br shaly soil	.1	.0004
	5-10′	10B	DBr soil w/shale chunks	.20	NA
	10-	10C	DBr soil w/shale chunks	.16	NA

the Ridgeley and Shriver, cut by holes 4 and 5, contain 0.4 to 0.7 percent P_2O_5, respectively. These results are similar to those obtained by Lotspeich and Markward (1963, p. F28) elsewhere, who state "samples from the soil overlying the (Phosphoria Formation) shales are higher in phosphorus . . . than are normal agricultural soils, whose phosphorus content seldom exceeds 0.1 percent by weight." The uranium content is approximately the same throughout the area. Fluorine was looked for but not found, and, if present, it is in minor quantities below the threshold of the analytical method used.

SUMMARY AND CONCLUSIONS

Phosphate occurrences are associated with the Ridgeley Sandstone of the Oriskany Group and equivalent formations at many localities in the Appalachian region of New York, Pennsylvania, Maryland, Virginia, and West Virginia. In most places the phosphate is in thin layers of oölitic shale of Onondaga age, or it occurs as isolated nodules of carbonate fluorapatite at the top of the Ridgeley Sandstone. Generally, the phosphatic material is either too thin or too low grade, and apparently too discontinuous to be of commercial interest. Weathering may increase the thickness of a phosphatic zone making it more amenable to mechanical mining operations. On the other hand, such weathering may also decrease the per unit grade of the deposit.

Mining and exploration of the Newman property shows that phosphate occurs both as tiny carbonate apatite oölites clustered in calcareous nodules at the top of the Ridgeley and also as the secondary minerals of aluminum phosphate, wavellite and crandallite, in weathered Shriver Chert below the Ridgeley.

Too little is known about the grade distribution and thickness of the Newman phosphate deposit to estimate reserves. The data, presented herein, may be sufficient, however, to suggest areas of further study by geologic surface mapping and modern exploration techniques should such resources become valuable in the future.

The following list summarizes what is known about phosphates in Devonian rocks of the Appalachian region at the present time and may serve as a general guide for future exploration:

1. Phosphatic material is found in oölitic shales of Onondaga age and also as nodules at the top of the Ridgeley Sandstone; secondary minerals in veinlets and vugs occur in the Shriver Chert below the Ridgeley.
2. Thickest concentrations of phosphatic material occur in areas where the Ridgeley is rather thin, especially near the eastern margin of the

Oriskany basin of deposition in Juniata, Perry, Huntingdon, Fulton and Franklin Counties of south-central Pennsylvania. Maps by Jones and Cate (1958) may be helpful in selecting areas of possible phosphate mineralization. Such areas might be examined first because of the known affinity of phosphorite with sediments of shallow marine origin.

3. Scintillation-type counters are useful in locating the contact of Onondaga Limestone and the top of the Oriskany where bedrock is thinly covered by colluvium. Where normal background is approximately 0.006 mr/hr, the Ridgeley Sandstone ranges from 0.009 to 0.012 mr/hr and the overlying shales range from 0.015 to 0.030 mr/hr.
4. Preliminary geochemical sampling near the Newman phosphate prospect shows 0.1 percent P_2O_5 in soils above Onondaga Limestone and soils distant from the deposit. Soils downslope from and near the workings range from 0.2 to 0.4 percent P_2O_5, while thin soils resting on phosphatic layers contain as much as 0.7 percent P_2O_5.
5. Detailed geological mapping along with soil and outcrop sampling and trenching across the Onondaga Limestone and Oriskany Group may reveal additional areas of phosphatic material in Juniata County and neighboring counties of Pennsylvania.

REFERENCES

Altschuler, Z. S., Jaffe, E. B., and Cuttitta, Frank (1956), *The aluminum phosphate zone of the Bone Valley Formation, Florida, and its uranium deposits,* U. S. Geol. Survey Prof. Paper 300, p. 495-504.

Cathcart, J. B. (1963), *Geology of the Keysville quadrangle, Florida,* U. S. Geol. Survey Bull. 1128, 82 p.

———, and McGreevy, L. J. (1959), *Results of geologic exploration by core-drilling, 1953, land-pebble phosphate district, Florida,* U. S. Geol. Survey Bull. 1046-K, p. 221-298.

Hovey, E. O. (1904), *Phosphate rock,* in U. S. Geol. Survey, *Mineral Resources of the United States, 1903,* Washington, D. C., U. S. Govt. Print. Off., p. 1047-1058.

Ihlseng, M. C. (1896), *A phosphate prospect in Pennsylvania,* U. S. Geol. Survey Ann. Rept. 17, pt. 3, p. 955-957.

Jones, T. H., and Cate, A. S. (1958), *Preliminary report on a regional stratigraphic study of Devonian rocks of Pennsylvania,* Pennsylvania Geol. Survey, 4th ser., Spec. Bull. 8, 5 p., 7 pls.

Lotspeich, F. B., and Markward, E. L. (1963), *Minor elements in bedrock soil, and vegetation at an outcrop of the Phosphoria Formation on Snowdrift Mountain, southeastern Idaho,* U. S. Geol. Survey Bull. 1181-F, 42 p.

Miller, B. L. (1925), *Limestones of Pennsylvania,* Pennsylvania Geol. Survey, 4th ser., Bull. M 7, 368 p.

Parker, E. W. (1901), *Phosphate rock,* U. S. Geol. Survey Ann. Rept. 21, 1899-1900, pt. 6, p. 481-502.

Schuchert, Charles, and others (1913), *The Lower Devonian deposits of Maryland,* Maryland Geol. Survey, Lower Devonian Volume, p. 67-190.

Shapiro, Leonard, and Brannock, W. W. (1962), *Rapid analysis of silicate, carbonate, and phosphate rocks,* U. S. Geol. Survey Bull. 1144-A, 56 p.

Stone, R. W. (1939), *The minerals of Pennsylvania—Nonmetallic minerals,* Pennsylvania Geol. Survey, 4th ser., Bull. M 18-C, 50 p.

Van Slyke, L. L. (1932), *Fertilizer and crop production,* New York, Orange Judd Pub. Co., 400 p.